



**The recently appointed National Park System Advisory Board** consists of (left to right): **Charles R. Jordan** (director, Parks and Recreation, Portland, Oregon); **Sylvia A. Earle** (marine biologist and ocean explorer); **Javier M. Gonzales** (Santa Fe County commissioner and former mayor of Santa Fe, New Mexico); **Margaret L. Brown** (former senior vice president of Cook Inlet Region, Inc., an Alaska native lands corporation); **Gary Paul Nabhan** (museum science director and natural history author); **Parker Westbrook** (former special assistant and administrative aide for Arkansas members of Congress); **Marie W. Ridder** (environmental advocate and journalist); **John Hope Franklin** (James B. Duke Professor Emeritus of History, Duke University); **Robert S. Chandler** (retired NPS superintendent); **Stanley Selengut** (civil engineer and creator of sustainable and ecologically appropriate resorts and businesses); **Thomas B. Williams** (retired Democratic staff director for the Senate Committee on Energy and Natural Resources); and **Shirley M. Malcolm** (science educator, ecologist, and administrator with the American Association for the Advancement of Science).

*Scientific management of natural resources has long been a precept of park resource managers. The National Park Service strengthened its commitment to this principle in 1999 when three prominent scientists were named to the National Park System Advisory Board. Their ability to link science to several key questions about the long-term direction of the National Park Service is sure to bring valuable insights. Other exciting news was the budget increase for the Inventory and Monitoring Program late in the year. This development will speed up acquisition of natural resource baseline inventories, giving parks a foundation for planning long-term ecological monitoring to detect changes in resource condition. In other areas, scientific data management is advancing through the development of computer interfaces and other tools or systems to afford park resource managers access to centralized databases of natural resource information. These and other developments reported here represent substantial progress for the year with respect to the scientific role of the National Park Service in managing park natural resources.*

## Leadership in Science

### NPS Advisory Board features strong science presence

by the editor

 [jeff\\_selleck@nps.gov](mailto:jeff_selleck@nps.gov)

Writer-Editor, Natural Resource Information Division; Natural Resource Program Center, Lakewood, Colorado

Secretary of the Interior Bruce Babbitt appointed a new National Park System Advisory Board in 1999 in response to a recent reauthorization of the board by the Congress. As in the past, the board's mission is to further the purposes of the national parks and the National Park Service. Its 12 members are a group of scholars, businesspeople, public servants, and philanthropists, each with credentials and a strong interest in the conservation of park resources and the role of the National Park Service in American life.

**"The advisory board features a strong natural resource science presence in the persons of Sylvia A. Earle, Gary Paul Nabhan, and Shirley M. Malcolm."**

John Hope Franklin, renowned historian, legal scholar, and cultural resource scientist, chairs the reinvigorated board. A culturally diverse and professionally balanced group, the advisory board features a strong natural resource science presence in the persons of Sylvia A. Earle, Gary Paul Nabhan, and Shirley M. Malcolm (see profiles of these board members on the following page).

After announcing the board in August, Director Stanton spelled out his charge in a December memorandum, asking the group to tackle several difficult and wide-ranging questions about the future of the parks and the National Park Service. How should the National Park Service reconcile resource protection with visitor enjoyment, and how should it protect park resources in changing landscapes? How should it respond to a changing population, and what is its role in education? How should the national park system grow? And how can the National Park Service strengthen its identity? In addition, Director Stanton emphasized that scientific inquiry, including preparation of papers by leading academicians and scholars, should be part of the process in addressing these tough issues.

A final report of the findings and recommendations of the board is anticipated in spring 2001. The report is expected to be visionary and to describe the future legacy of the national parks and the role of the National Park Service in conserving the nation's natural and cultural heritage.

The National Park Service is excited about the anticipated insights and guidance of the board. It is also hopeful that the board's development of the report will stimulate a new level of public interest in the role of the national parks and the National Park Service in the life of the nation.

## Scientist Profiles

### SYLVIA A. EARLE—MARINE BIOLOGIST AND OCEAN EXPLORER



In addition to her work as a marine biologist, Sylvia Earle is an author, lecturer, scientific consultant, and spokesperson for SeaWeb. She is founder and chair of Deep Ocean Exploration and Research, director of Sustainable Seas Expeditions, former chief scientist of the National Oceanic and Atmospheric Administration, and the 1998–2000 explorer in residence at the National Geographic Society. She also serves on the boards of various nonprofit organizations, including the Woods Hole Oceanographic Institution, the World Resources Institute, the Center for Marine Conservation, and several others. She sits on the Visiting Committee in Ocean Engineering for the Massachusetts Institute of Technology. Holder of several diving records, Dr. Earle has led more than 50 expeditions and has authored more than 120 scientific, technical, and popular publications.

Her research concerns the ecology of marine ecosystems (see her article on the state of ocean resources on page 61) with special reference to marine plants and the development of technology for access and research in the deep sea. During more than 6,000 hours of diving, Dr. Earle has observed deterioration of ocean resources. Due to her awareness that most of the planet's oceans are unexplored, she has become an advocate of exploration, research, and protection of marine ecosystems. Her broad expertise in ecological issues concerning marine resources and science and research in general is sure to serve the National Park System Advisory Board very well.

### GARY PAUL NABHAN—MUSEUM SCIENCE DIRECTOR AND NATURAL HISTORY AUTHOR



Gary Nabhan resides in Tucson, Arizona, where he is director of conservation and science at the Arizona–Sonora Desert Museum. A versatile scientist with teaching experience in economic botany at Arizona State University and in the literature of natural sciences at the University of Arizona, Dr. Nabhan is a prolific writer. He has published more than 60 technical journal articles in botany, geography, nutritional ecology, conservation biology, linguistics, anthropology, education, and regional studies literature. Additionally, he has authored more than 200 magazine articles, poems, essays, and short stories. His books include *Plants and Protected Areas* (with John Tuxill, 1998, Stanley Thornes, Ltd.); *Forgotten Pollinators* (with Stephen Bachman, 1996, Island Press); *Canyons of Color* (with Caroline Wilson, 1995, HarperCollins/West); *Saguaro* (with George Huey, 1986, Southwest Parks and Monuments Association); and *The Desert Smells Like Rain* (1982, North Point).

As director of conservation and science, Dr. Nabhan oversees a very active desert research program that includes studies in botany and ethnobotany, ecology, herpetology, invertebrate zoology and ichthyology, mammalogy and ornithology, geology, and outreach and education. In addition he serves as the principal investigator on several projects examining the relationships among native Sonoran Desert peoples, plants, and animals. One of these is a monitoring study of four migratory pollinators that move between western Mexico and the southwestern United States. This binational project incorporates local community participation in an effort to identify and develop stewardship for vulnerable habitats. His knowledge and expertise of desert ecosystems; research and its administration; outreach; and natural history education, writing, and literature are very useful scientific credentials for the work of the National Park System Advisory Board.

### SHIRLEY M. MALCOLM—ECOLOGIST AND SCIENCE EDUCATOR



Shirley Malcolm is head of the Directorate for Education and Human Resources Programs, American Association for the Advancement of Science (AAAS), in Washington, D.C. In this capacity, Dr. Malcolm designs, implements, and manages a complex array of programs and projects aimed at achieving AAAS goals of advancing education in science, mathematics, and technology and expanding the talent pool for science. The directorate is the hub of a large and active network of policy makers, advocates, and practitioners working to bring science to the people, and people to science. Earlier, she worked as program manager of the Minority Institutions Science Improvement Program for the National Science Foundation.

In her leadership role with the AAAS, Dr. Malcolm has helped advance science education in the United States, especially for groups who traditionally underparticipate in education and careers based in science. To address these concerns she led the creation and development of the Black Churches Project, a network of churches designed to bring science, environment, and health education to African Americans. Likewise, Proyecto Futuro is a program to connect science learning in the school, community, and home by developing bilingual materials and showing connections between science and Latino culture. She has also guided science learning programs designed especially for children.

Dr. Malcolm serves on numerous boards, including the National Science Board and the President's Committee of Advisors on Science and Technology, both by appointment of the President, and the board of the American Museum of Natural History. Her perspectives on science education and her experience in attracting people to science careers will go far in serving the interests of the National Park Service and the National Park System Advisory Board.

## Resource Inventory and Monitoring Natural Resource Challenge benefits Inventory and Monitoring Program

by Gary Williams

[gary\\_williams@nps.gov](mailto:gary_williams@nps.gov)

Inventory and Monitoring Coordinator, Natural Resource Information Division; Natural Resource Program Center, Fort Collins, Colorado

Natural resource inventory and monitoring are two of the major activities included in the National Park Service's Natural Resource Challenge ("the Challenge"). Those components of the Challenge will be carried out through the NPS Inventory and Monitoring (I&M) Program.

**"The NPS I&M Program received a base increase of \$7.3 million [during the first year] of the Challenge."**

In fall 1999, as fiscal year 2000 got under way, the NPS I&M Program received a base increase of \$7.3 million, the first in a series of budget increases planned to be requested over the five-year life of the Challenge. In FY 2000 the increase was for accelerating the completion of 11 of the 12 basic inventories initiated by the program in 1992. A portion of the increased funding will be provided to the regions to hire permanent, full-time inventory coordinators. One FTE (i.e., full-time equivalent or full-time staff) and the associated salary and support funds will be provided to each region. One million dollars of the FY 2000 increase will be used to supplement existing program funds for completing abiotic inventories (soils, geology, water resources, etc.). The remaining funds, approximately \$6 million, will be used to fund inventories of vertebrates and vascular plants in parks. The Park Service has estimated that the increased funding for inventories received in FY 2000 will allow it to complete all of these basic resource inventories in about seven to eight years.

The 12th inventory component, vegetation mapping, will not be funded out of the increase received in FY 2000, since the USGS Biological Resources Division (BRD) has primary responsibility for funding vegetation mapping for all units of the national park system outside of Alaska. A funding increase is included in the FY 2001 Natural Resource Challenge budget request so that the National Park Service can share the costs of vegetation mapping with the USGS BRD and accelerate the completion of those maps over what would occur with only USGS BRD funding.

In addition to accelerating completion of basic natural resource inventories, the National Park Service designed and adopted a strategy for implementing ecological monitoring throughout the national park system as called for by the Challenge. Under this strategy, all of the natural resource parks have been assigned to one of 32 separate monitoring networks. Ecological monitoring will be implemented on a network-wide basis, with the most critical ecological variables, or indicators of ecosystem health, to be monitored in the parks of each network. Parks within a given network are expected to function as a team and share professional expertise, administrative workloads, and other burdens. The first fiscal year of funding for this monitoring strategy has been requested for FY 2001. Five of these monitoring networks, involving 55 park units, will be implemented during FY 2001, if Congress provides funding. Monitoring in the remaining 27 networks will be phased in over a period of three years if funding is appropriated. Monitoring in the 32 networks is in addition to the ecological monitoring being conducted by Prototype Long-term Ecological Monitoring (LTEM) Programs, which are already functioning. The LTEM Programs will continue to receive support for conducting the more comprehensive and intensive monitoring studies. Prototype LTEM programs will provide mentoring and other technical assistance and products to parks throughout the national park system.



Lisa Thomas, Great Plains Prairie Cluster

**Staff prepare to use plastic hoops** for sampling prairie vegetation in permanent plots in Scotts Bluff National Monument, Nebraska. Long-term ecological monitoring reveals changes in the structure and species composition of plants. Such information is indispensable for evaluating grassland communities and for determining the effectiveness of restorative measures such as prescribed fire, seeding, plantings, and control of exotic plants.

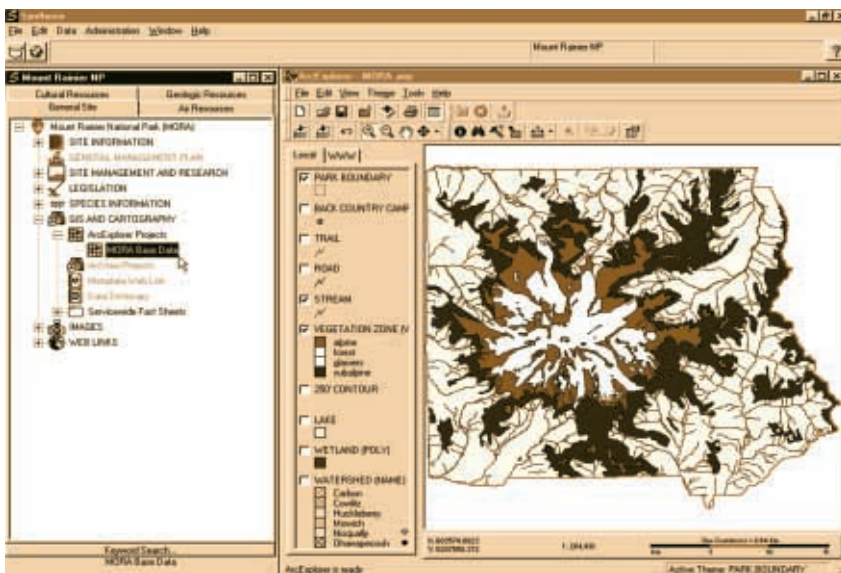
### Special amphibian inventories

*As part of its servicewide inventories of vertebrates, the National Park Service will contribute \$940,000 during FY 2000 in support of the Amphibian Research and Monitoring Initiative (ARMI), an interagency effort on Department of the Interior lands under the leadership of the USGS Biological Resources Division. The NPS funding will be used for specialized inventories of amphibians in 12 of the 14 PRIMENet parks. PRIMENet, which stands for Park Research and Intensive Monitoring of Ecosystems Network, is a joint EPA-NPS program to assess the effects of environmental stressors on ecological systems across the country. Future amphibian inventories will be integrated into other vertebrate inventory strategies for non-PRIMENet parks.*

## List of fossil parks expands

Understanding of the fossil record expanded in 1999 as more than a dozen parks not formerly known to have paleontological resources joined the list of 144 parks that do. A dedicated team of paleontologists and student interns undertook exhaustive searches to uncover any occurrences of fossil plants, animals, and their traces in units of the national park system. The baseline data are being compiled to support the management, protection, and interpretation of these nonrenewable remains of past life and to better understand ancient ecosystems.

Synthesis users select elements from the user interface to reveal information and data. Mount Rainier's use of Synthesis allows for retrieval of both park-specific and park system-wide information. In this example a GIS map shows stream locations and vegetation types for application in watershed planning.



## Information Management and Technology AQUIMS becomes "Synthesis"

by Bruce Nash

✉ bruce\_nash@nps.gov

Ecologist and Synthesis Coordinator, NPS Natural Resource Information Division; Natural Resource Program Center, Lakewood, Colorado

During 1999 an enhanced version of the Air Quality Information Management System (AQUIMS) software was integrated with the NPS Geographic Information System (GIS) Data Browser, creating the new information management system "Synthesis." In September, Synthesis was designated as the new standard interface for organizing and disseminating natural resource information within the Natural Resources Directorate. Synthesis represents a national information management effort involving representatives from the NPS Natural Resources Directorate, Cultural Resources Directorate, Information and Telecommunications Center, park and regional offices nationwide, and researchers at Penn State and the University of Denver. The Synthesis project is one component of an enterprise data management system planned by the Natural Resource Data and Information team who will also develop data management standards, quality assurance protocols, and tighter integration of Natural Resource Program Center databases if a related FY 2001 Natural Resource Challenge budget request is successful.

Synthesis is an information management system for efficiently locating, organizing, integrating, and disseminating data and information. It does not replace existing databases or dictate the structure or function of other databases. Rather it provides a set of pathways that link various sources of information. Synthesis presents the user with a simple, graphical user interface

that functions as a gateway to information that may be stored on local computers, networks, intranets, or the Internet. From this single gateway a user may view and integrate many types of information, including text-based documents, photographic libraries, databases, spreadsheets, presentation graphics, GIS data, bibliographies, Internet-based information, and decision support systems.

All information, including periodic updates, will be distributed in standard NPS formats via either the Internet or CD-ROM. In addition to providing natural resource information from a standard interface, Synthesis includes a software toolbox that allows users to create a custom interface and then link information to that interface. An interface created in this manner can be designed to serve park-specific information needs. No programming expertise is needed to use the toolbox.

**"Synthesis is an information management system for efficiently locating, organizing, integrating, and disseminating data and information."**

Synthesis is already functional in some parks. At Mount Rainier (Washington), Resource Manager Barbara Samora reports that Synthesis was "used in seasonal training, for developing information needed for environmental assessments, and for pulling together information requested by the USDA Forest Service for use in their watershed planning efforts." Darin Swinney, a GIS specialist at Mount Rainier, and Samora have customized the Synthesis interface to accommodate Mount Rainier-specific files, which they have added to the system. Because these files were sent to the Synthesis development team, they are now available to other parks, regions, and central offices. This is an excellent example of how Synthesis improves the dissemination of information.

At Petersburg National Battlefield (Virginia) a multi-disciplinary team is working with park staff to improve all aspects of information management, including hardware and software issues, communication capability, and data management. Together this team will enter natural and cultural information into Synthesis and its integrated "sister" systems (NPS GIS Data Browser and NPS Cultural Resources MAPIT). This effort will improve information management at Petersburg and develop protocols and standards that will be used across the national park system.

## Natural and Cultural Resource Protection

## Preserving the Cape Hatteras lighthouse ... and the coast

by Steve Harrison

✉ steve\_harrison@nps.gov

Chief of Resource Management, Cape Hatteras National Seashore, North Carolina

In 1999 the Cape Hatteras Light Station was successfully relocated 2,900 feet from the spot on which it had stood since 1870. Because of the threat of shoreline erosion, a natural process, the entire light station, consisting of four historic structures, was safely moved to a new site where the buildings were placed in relation to each other, exactly as they had been at the original site. While the National Park Service has met its obligation to both historic preservation and coastal protection, the much-heralded move of the historic buildings was hotly debated and closely watched.

When constructed in 1870, the Cape Hatteras lighthouse was located a safe 1,500 feet from the ocean. Even then, however, storm-driven tides completely washed over Hatteras Island, eroding sand from the ocean side of the island and depositing it on the sound side. By 1970, this process, which has caused the gradual westward migration of the Outer Banks for at least the past 10,000 years, left the lighthouse just 120 feet from destruction.

The National Park Service has long recognized the threat to the lighthouse posed by the erosion process and began a series of measures to protect the historic structures as early as 1930. In the decades leading up to the relocation of the lighthouse, numerous interim protective actions were taken to slow the erosive power of the ocean and save the lighthouse in place.

These included sand replenishment, sandbagging, and maintenance of erosion-control or groin structures. Despite these human efforts, the power of the ocean did not abate and the waves continued to break closer and closer to the lighthouse.

In 1980 the National Park Service began planning, under the National Environmental Policy Act, for long-term protection. A three-year process that included public meetings yielded several alternatives. Relocation was considered but quickly discounted as impractical. The option finally selected was a seawall revetment that would have protected the lighthouse in place but would eventually have created an island as the coastline receded to the southwest. When additional information became available about relocation versus the approved seawall, the National Park Service examined the alternative that allowed it to accommodate natural processes while still preserving the historic structures of the light station.

In 1987, to quickly resolve the issue, the National Park Service contracted for assistance from the National Research Council of the National Academy of Sciences in developing long-term options for preserving the Cape Hatteras lighthouse. The committee formed to address this question considered all options, but recognized that the National Park Service ultimately would have to make its decision in the context of NPS policy, the various public policies relating to U.S. coastlines, and scientific and engineering constraints. Both NPS policy and state law (Coastal Area Management Act) precluded additional temporary protective measures or hardening of the coast for long-term protection. In its report, *Saving Cape*



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**Moving the 4,800-ton lighthouse** was no small engineering feat. Contractors employed 100 jacks to keep the lighthouse level while five hydraulic rams gently nudged it along iron beams lubricated with soap to its new resting place 2,900 feet away. The operation went smoothly, taking 23 days and causing no damage to the 130-year-old treasure.



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**Battered by perennial ocean storms**, the shoreline at Cape Hatteras National Seashore had become a precarious home to the famous black-and-white lighthouse and four associated historic buildings. After years of study the National Park Service opted in 1999 to move the structures and cleared a pathway to a safe haven 1,600 feet from the shoreline.

## Deer management EIS survives lawsuit

*Held up for nearly two years in federal district court, the White-tailed Deer Management Program of Gettysburg National Military Park and Eisenhower National Historic Site (Pennsylvania) was reinstated by the court in January 1999. The suit was brought by three animal rights organizations and six citizens in 1997 who opposed the National Park Service deer management program. However, the court ruled that the Park Service had "considered a full range of reasonable alternatives and was within its discretion" when it chose direct reduction through shooting as the method of reducing deer numbers to the goal of 25 deer per square mile of forest. There is no public hunting. The court also ruled that the Park Service "acted consistently with the Organic Act ... and that it complied with the ... National Environmental Policy Act and the National Historic Preservation Act."*

*The Park Service conducted more than 10 years of research and completed an environmental impact statement (EIS) that examined alternatives for reducing white-tailed deer populations at the parks. The studies concluded that the parks have more deer than the natural and historic landscape can support. Intensive deer browsing is preventing tree seedlings from becoming established, and historical crops are being destroyed before they can be harvested. The 1995 EIS, which included public review, considered all feasible options for meeting park objectives, including public hunts, animal relocation, and sterilization and contraception.*

*Hatteras Lighthouse from the Sea: Options and Policy Implications* (full text available at [www.nps.gov/caha/lrp.htm](http://www.nps.gov/caha/lrp.htm)), the committee evaluated 10 options for preserving the lighthouse, but recommended incremental relocation as the preferred alternative. The National Park Service also considered this the best overall solution in that it would preserve the structures and accommodate the natural shoreline processes.

Nevertheless, many people feared destruction of the brick lighthouse, the tallest in the United States. As a result, in 1996, North Carolina State University (NCSU) independently reviewed the National Academy of Sciences report, and then issued its own report, *Saving the Cape Hatteras Lighthouse from the Sea*, in January 1997. It not only supported the findings of the


National Academy of Sciences report, but also recommended that "the National Park Service proceed as soon as possible with its present plans to obtain the financial resources necessary to preserve the lighthouse by moving it." Funding was appropriated by Congress beginning in FY 1998.

Management decisions of this magnitude in national parks are based on laws and regulations through a public planning process. The decision to relocate the Cape Hatteras Light Station was a sound public policy decision based on the best science and engineering available, and on 9 July 1999, the Cape Hatteras Lighthouse reached its new home. Now safely 1,600 feet from the ocean, it should not be threatened by the indomitable ocean waves for another 100 years.

## Scientific Design

### Reducing the hazards of open mine shafts in parks

by Philip Cloues

 [phil\\_cloues@nps.gov](mailto:phil_cloues@nps.gov)

Mining Engineer and Mineral Economist, Geologic Resources Division; Natural Resource Program Center, Lakewood, Colorado

As odd as it sounds, accidentally falling into an abandoned mine shaft while hiking or exploring is a possibility in approximately 140 units of the national park system. The Abandoned Mineral Lands Program of the NPS Geologic Resources Division is responsible for addressing problems, including safety concerns and environmental degradation, associated with abandoned mines in parks. Polyurethane foam (PUF) can be used to form a plug or stopper at the top of a mine shaft to prevent the accidental falls of humans and wildlife. Research sponsored by the National Park Service and completed in 1999 by a team of senior engineers at the Colorado School of Mines in partnership with the Bureau of Reclamation's Materials Engineering and Research Division developed a PUF plug design with reduced cost and other benefits. In this case, "doing more with less" is a reality through innovation.

Polyurethane foam has been used for mine shaft closures for over two decades. However, it usually requires equipment and mechanical transportation that can leave a footprint on sensitive soils and disturb other natural resources and sensitive cultural landscapes. Equipment-free, bagged PUF is transported in backpacks, mixed by hand in its plastic-bag container, and installed without a proportioning unit and portable generator. The method is a proven long-term alternative to heavy concrete caps, steel grates, fences, and total backfill. The 1:30 expansion factor from liquid to solid is an added plus in reducing material transported to the site.

During the 1999 research the Senior Engineering Design Project focused on design and material properties testing (e.g., density, compression, tension, and shear strength). The team minimized the amount of testing by first generating finite element analysis using computer modeling. Full-scale testing on the 2,500-ton hydraulic press at the Bureau of Reclamation followed bench modeling at the School of Mines engineering laboratory in Golden, Colorado. One benefit of the new design is that cardboard shipping containers are incorporated in the plug and need not be removed from the site. Other benefits are reduction in PUF volume per shaft closure, material cost savings of about \$500 per closure, less installation time, and tested strength reliability. The foam left over from the tests was put to use at Fort Bowie National Historic Site in Arizona to close an abandoned mine shaft at no cost to the park.

Equipment-free PUF may provide a long-term solution in areas with limited access and sensitive natural resources and cultural landscapes. The stabilization of the shaft collar with lightweight rigid foam can prevent collapse and stop the problem from getting larger over time. Polyurethane foam transforms from a liquid to a solid in about six to eight minutes. A typical 25-square-foot PUF shaft plug is only 6–7 feet thick and can support a load of 30 tons. Additionally, although in some cases the plug is vented, it reduces the amount of water seeping into the shaft, thereby decreasing the potential for mineral contamination of groundwater. Tested during 1999, the new PUF plug design will improve park safety and reduce resource impacts from mine shaft closures in many units of the national park system.

## Real-time Information

## Monitoring air quality during fire at Grand Canyon

by Tonja Opperman and Kara Leonard

✉ tonja\_opperman@nps.gov

Fire Effects Specialist, Grand Canyon National Park, Arizona

✉ kara\_leonard@nps.gov

Fire Effects Crew Leader, Grand Canyon National Park, Arizona

With a new national wildland fire policy and a prescribed fire management program emphasizing landscape-scale ignitions, fire played a beneficial role in over 12,000 acres of Grand Canyon's forests in 1999. Although managed fires produce unique resource benefits, they also create large volumes of smoke. Because the park receives the highest level of protection under the Clean Air Act as a Class I area, this smoke creates resource management conflicts. Fire managers work with the Arizona Department of Environmental Quality (ADEQ) to ensure that smoke emissions do not violate air quality standards. For the first time, in 1999 the park combined many technologies to provide real-time information to the Department of Environmental Quality. This allowed regulators and managers to make better, science-based decisions concerning the air and forest resources under protection.

**"The Arizona Department of Environmental Quality used the real-time smoke information ... to decide if the park could allow existing fires to continue burning naturally."**

Fire monitoring personnel used DataRAM 2000 portable air-sampling machines to measure particulates in populated areas. During significant fire activity, fire monitors downloaded the data every evening and created graphs of particulate levels from the previous 24 hours. Several times each day, they took digital photographs from the same vantage points to record the presence or absence of smoke in the canyon. To accompany the photos, they wrote a description of the color, volume, location, and movement of the smoke column. Finally, the fire monitors sent all of this information to state regulators daily via e-mail.

While the fires were actively producing smoke, fire managers discussed management options each morning with ADEQ decision makers 200 miles away. The ADEQ used the real-time smoke information in combination with weather forecasts to decide if the park could allow existing fires to continue burning naturally, and even ignite addi-

tional prescribed fire acres. In the past the park collected data that could not be used in a real-time fashion; decisions were based solely on a monitor's written description. Now regulators can better understand the dynamic nature of smoke using the daily digital photos and particulate information. They know that excessive smoke levels will be recognizable almost immediately. As a result the ADEQ has increased confidence in the park's ability to manage smoke, allowing Grand Canyon National Park to take advantage of additional burning opportunities.

Managing smoke is a complex process, and even the best technologies do not predict smoke movement or weather patterns with complete accuracy. The park's science-based monitoring system allows fire managers and air quality regulators to make informed decisions based on detailed and timely information. The ADEQ is now better able to work with park fire managers to allow a burn to continue, rather than stop it entirely on the basis of air quality concerns. The improved relationship between Grand Canyon National Park and the ADEQ helps balance stringent air quality standards against the ecological need for fire. The park continues to learn from the past and to refine smoke management techniques, ensuring that air quality is protected, while fire—with its smoke—remains an integral part of the Grand Canyon landscape.



**Prescribed fire poses a dilemma** for the National Park Service: how to conduct burns without violating air quality health standards. In 1999, fire managers at Grand Canyon National Park began to deploy air particulate samplers in areas of the park where people stay overnight. While this technology does not measure air pollutants such as volatile organic compounds or ozone, it does provide real-time information on particulates associated with fire, which are a concern for human health and visibility.



**Placement of the air particulate sampler**, the DataRAM 2000, is determined a few weeks before the burn. Samplers are located where human populations are greatest near the prescribed burn. The units are placed in standard fire weather stations before the fire is ignited and left in place until after the fire is out, which allows staff to monitor background particulates before smoke is in the air. Although it is not an EPA-referenced method for particulate sampling, the DataRAM 2000 has the advantage of providing real-time information, which staff download daily for use in making fire management decisions. The park currently uses three DataRAM units.